APPLICATION OF REMOTE SENSING IN VEGETATION STUDIES AND HABITAT MANAGEMENT OF THE AZORES

Workshop “The use of sentinel data for supporting land and marine spatial planning and management – specificities of small oceanic islands”

Eduardo Dias
Dinis Pereira

Email: edias@uac.pt

Ponta Delgada | Workshop ESA - NEREUS | 28 de setembro de 2015
Research Group, centered in the University of the Azores, which focuses in Applied Vegetation Ecology, with three investigation vectors:

1 – Descriptive research
2 – Analytical research
3 – Modelling and support to decision
1 – Descriptive and analytical research
Field surveys and flora and habitats mapping
Field surveys of flora and habitats mapping: Rapideye as a tool to help vegetation mapping (RAMSAR Area in Terceira Island)

Rapideye imagery helps in the spectral differentiation of some major vegetation formations.

Drone Aerial photo helps in vegetation formations that have punctual distribution.

(Rapideye - "Data provided by the European Space Agency")
Natursa 2000: distribution patterns of species and habitats

*Sphagnum sp.*

4050 - Matos macaronésicos

(Rapideye - "Data provided by the European Space Agency")
Analysis of distribution patterns of rare species and habitats

Field surveys are inserted in GIS database

Field surveys of rare plant species and habitat classification

GIS allows the analysis of vegetation types and distribution patterns

Peat Bogs types and distribution at Terceira Island - GEVA
2 – Modelling and support to decision
Modelation of potential distribution of natural Azores Forests and habitats

Model of potential distribution of natural Azorean Forests – FORESTAÇOR © - for Pico da Vara

LIFE-SPEA Laurissilva

Model of potential distribution of peatlands, for Pico da Vara

LIFE-SPEA Laurissilva
Modelation of Ecological Optimum for plants species

Ecological Optimum for *Cryptomeria japonica*

Ecological Optimum variables for *Picconia azorica*
Spatial analysis of biodiversity for ecological corridors on protected areas

“WETREST- WET ISLANDS RESTORATION - Insular Wetland Restoration: Renaturalization Processes and Biodiversity Valorization in Environmental Management”

"Project proposal for free access to RapidEye satellite imagery (3rd party missions) from the European Space Agency to wetland conservation and monitoring in Azores."
(Rapideye - "Data provided by the European Space Agency")

- The importance of peatlands and impact on the island environment
- Tools to restore the peatland and landscape stability capacities and biodiversity.
- Establishment of intervention strategies for regenerative capacity of natural ecosystems.
Study of secondary regenerative succession of Azorean Mires, after anthropogenic pressure, as an ecological restoration tool

*Sphagnum* distribution in Lagoa do Negro Experimental Field. The *Sphagnum* distribution area corresponds with the presence of *Sphagnum*, even in other vegetation communities.
The Biodiversity Monitoring is necessary to overcome two central problems to the certification process:

- To ensure that the minimum practiced standards are, in fact, at levels of minimum performance in the field (often called "efficacy of monitoring");

- Assess the extent to which existing management standards are appropriate and how these can be refined to ensure continued progress in the long-term, toward established conservation goals (often called "monitoring validation"). This is essentially the same as the applied research, as it provides a useful mechanism to learn how to improve biodiversity conservation opportunities within the certification process.
Monitorization of the change of use and land cover changes in the landscape using Remote Sensing

Landsat 8 image with the study area (red)

Drone survey of the area (area 1, in the first picture)

Drone Aerial photo and training points of various land uses (yellow points)

Supervised classification of the landscape, in Landsat 8
Remote sensing as a tool to monitor renaturalization measures after production forest cuts

Oblique aerial photo of a forest cut

Oblique aerial photo of a forest cut

Land cover provided measures to the area

Aerial photo of the forest cut area, that can be used to monitorize the land cover provided measures
Monitorization of the vegetation evolution using Normalized Difference Vegetation Index (NDVI) in Landsat 8

Landsat 8 image of the study area (10/8/2015)

Landsat 8 image of the study area (bands 5,4,3) with forest cut areas

NDVI applied to the Landsat. The forest cut areas revealed values near zero (areas covered with few vegetation)
Monitorization of the distribution of *Sphagnum*, using Landsat 8 and Drone

Landsat 8 image with the study area (red)

Oblique aerial photo of peat bog (area 1, in the first image)

Training points of *Sphagnum* sp, in the Drone Aerial photo (yellow points)

Distribution of *Sphagnum* Sp. (area 1 of the first image), in Landsat 8, according to his spectral signature
Clouds in aerial photo. Drone as a solution

Study area
(Source of the Photo: Google Earth)
Landslides, ecosystems resilience and pioneer communities

Aerial photo (Google Earth) showing landslides in S. Miguel

The same landslides in Rapideye and Landsat 8

The same landslides in aerial photo from drone

The drone has the possibility to oblique aerial photos, allowing better resolution of the area
Modelling of ecosystem services such as carbon sequestration, water retention and biodiversity

Location of the study area in Terceira island

Aspect of the study area, with the presence of *Sphagnum* sp. and hydromorphic habitats

Presence of *Sphagnum*, according to the analysis of the Rapideye

Validation of the presence of *Sphagnum* (Rapideye - "Data provided by the European Space Agency")
Modelling of ecosystem services such as carbon sequestration, water retention and biodiversity

Ground-penetrating Radar applied to stratigraphy of the hydromorphic habitats

Core sampling of the hydromorphic habitats

Laboratory measurements of water and Carbon

GIS modellation scenarios of water and Carbon stocks and sequestration
Sentinel-2

Potential applications in Ecological management and vegetation mapping
Copernicus/GMES data policy:

"Full and open access to Sentinel data for all users." [1]

<table>
<thead>
<tr>
<th>Mission</th>
<th>Description</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1A/B</td>
<td>Radar Mission</td>
<td>3 Apr 2014</td>
<td>early 2016</td>
</tr>
<tr>
<td>S2A/B</td>
<td>High Resolution Optical Mission</td>
<td>June 2015</td>
<td>2016</td>
</tr>
<tr>
<td>S3A/B</td>
<td>Medium Resolution Imaging and Altimetry Mission</td>
<td>end 2015</td>
<td>2017</td>
</tr>
<tr>
<td>S4A/B</td>
<td>Geostationary Atmospheric Chemistry Mission</td>
<td>2021</td>
<td>2027</td>
</tr>
<tr>
<td>S5P</td>
<td>Low Earth Orbit Atmospheric Chemistry Mission</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>S5A/B/C</td>
<td>Low Earth Orbit Atmospheric Chemistry Mission</td>
<td>2021</td>
<td>2027</td>
</tr>
<tr>
<td>S6A/B</td>
<td>Altimetry Mission</td>
<td>2020</td>
<td>2025</td>
</tr>
</tbody>
</table>

Sentinel-2 can be interesting in vegetation studies and habitat management of the Azores.

Habitat Automatic Classification – Limitations. Can Sentinel help?

**Landsat 8** with iso cluster unsupervised classification with 15 classes

Peat Bogs types and distribution at Terceira Island - GEVA
Hydrological Availability Annual Index (IADH) – can Sentinel-2 help?

**Rapideye** with iso cluster unsupervised classification with 15 classes, only showing the ones that intersect pastures

**Landsat 8** with iso cluster unsupervised classification with 15 classes, only showing the ones that intersect pastures
Special habitats – can Sentinel-2 help find them?

Thermophilous habitats in volcanic fields

Google Earth photo of the Fumarolas, in Terceira island (a), a thermophiles habitat. The thermal irradiation was no possible to be identified in Rapideye NIR band (b), or in band 5, 10 or 11 of Landsat 8 (c, d and e). More *investigation*, or more *spectral and spatial resolution* are needed.

Drone aerial photography of Fumarolas, in Terceira island
Sentinel-2 is a polar-orbiting, multispectral high-resolution imaging mission for land monitoring to provide, for example, imagery of vegetation, soil and water cover, inland waterways and coastal areas. Sentinel-2 can also deliver information for emergency services [2].

- Free?
- Monitorization with 10 to 60 m of spatial resolution?
- Objective to provide cloud-free products typically every 15 to 30 days over Europe and Africa. And about the Azores?
- Revisit time (problems with clouds) of 5 days?
- 13 spectral bands!
- Will be possible to minimize the problem of too much water in Azores (in the grasslands, for instance), to differentiate landscape elements (maybe with the 3 RedEdge bands)?
- Indices, such as leaf area index, leaf chlorophyll content and leaf water content can be a problem with too much water.
- Monitorization of forestation?
- Landslides?

### Spectral bands (center wavelength in nm/SSD in m)

<table>
<thead>
<tr>
<th>Bands</th>
<th>Mission objective</th>
<th>Measurement or calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (443/20/60), B2 (490/65/10) &amp; B12 (2190/180/20)</td>
<td>Aerosols correction</td>
<td></td>
</tr>
<tr>
<td>B8 (842/115/10), B8a (865/20/20), B9 (940/20/60)</td>
<td>Water vapor correction</td>
<td>Calibration bands</td>
</tr>
<tr>
<td>B10 (1375/20/60)</td>
<td>Circus detection</td>
<td></td>
</tr>
<tr>
<td>B2 (490/65/10), B3 (660/35/10), B4 (665/30/10), B5 (705/15/20), B6 (740/15/20), B7 (775/20/20), B8 (842/115/10), B8a (865/20/20), B11 (1610/90/20), B12(2190/180/20)</td>
<td>Land detection, Land cover classification, Leaf chlorophyll content, leaf water content, LAI, fAPAR, snow/ice/cloud, mineral detection.</td>
<td>Land measurement bands</td>
</tr>
</tbody>
</table>

[2] - http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Overview4
Thank you!

For more information:

- Mendes (In development). Study of secondary regenerative succession of Azorean Mires, after anthropogenic pressure, as an ecological restoration tool.